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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : G09B 9/052, 19/16	A1	(11) International Publication Number: WO 00/31712 (43) International Publication Date: 2 June 2000 (02.06.00)

(21) International Application Number: PCT/SE99/02207

(22) International Filing Date: 26 November 1999 (26.11.99)

(30) Priority Data:
9804124-7 26 November 1998 (26.11.98) SE

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(81) Designated States: AU, BR, CA, CN, CU, CZ, HU, IL, JP, KR, MX, NO, NZ, PL, RU, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.
In English translation (filed in Swedish).

(54) Title: METHOD TO DECIDE THE HANDLING PATTERN OF THE CONTROLS FOR A DRIVER

(57) Abstract

The present invention relates to a method and an equipment to map the control handling pattern of a driver by using comparing and predicative mathematic models. The method is characterized in that comparing and predicative mathematic models are used which models being obtained by using a multi variate data analysis of the information flow of continuously recorded information in connection to a correct vehicle behaviour during travel of a predetermined test track and during predetermined and set conditions.

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Especially the present invention relates to a method to map the control handling pattern of a driver by using comparing and predicative mathematic models. The invention also discloses use of said map to suggest a supplementary training to develop and enhance the basic skill/control handling pattern and in that way simultaneously form the base from which a quality guarantee of the driver training can be performed regarding said basic skill/control handling pattern. The invention also discloses an equipment to perform said method.

The usual way to train people to drive a car is intellectually oriented. The pure basic skill will be gained first after several hundres miles and close escapes out in the traffic, i.e as risks among other road-users.

More precisely the invention relates, in an embodiment, to an invention to map the behaviour patterns of the driver/vehicle by using a so-called logging system where several variables are measured at the same time, e.g. acceleration/deceleration, i.e. g-forces and changes of g-forces, preferably in the horisontal plane, turning of the steering wheel, the handling of the pedals, revs of the engine, etc during different (also severe) drivning conditions, at the same time as the driver is training certain moments to build up his or hers basic skill on a reflex level. These variables are measured continously during the moments, i.e. a certain amount of measurements per unit of time. Each observation, i.e measurement at a certain point, is a vector being a quantitative description of the behaviour of the driver at this very point. For a certain driver and measure round these vectors can be collected to a data matrix. Such a matrix will then be a quantitative description of the behaviour of the driver during the whole training session.

Thus the object of the present invention is to disclose a method to map possible weaknesses or shortages in the drivers basic skill of handling a vehicle, and with this map as a base, direct the training onto the skills needed to be there in one hand to make the driver feel comfortable and safe in the role as a vehicle driver and responsible for a safe driving, but also to make the fellow road-users feel safer together with "unexperienced" young drivers out on the roads. Thus the invention is disclosed to train elementary handling of the vehicle in a way making the skill incorp-

orated in the autonomous nervous system, i.e as reflexes already in an early stage during the driver training to as far as possible decrease the risk of getting said experiences in the hard way out on the open roads among fellow road-users in close escapes maybe releasing panic reflexes.

It is important that the brain has well developed behaviour patterns or references (made experiences) to, during a very alert decision-making process, be able to correctly estimate information (impressions) and to be able to reflectively choose the right handling pattern in a narrow escape. Thus in a critical close escape the driver does not have to be seized with panic and completely entrust himself or herself to a mere chance and/or to the built in passive safety of the vehicle, if any. Instead of that the driver is capable to interpret the situation in an early stage and to react fast and reflextively correct. To succed in this a basic faith to his or hers own actual capability is of decisive importance.

An interesting observation in this context is that a clear consiousness of an incapability to handle something involving a risk will lower the panic threshold, i.e. the probability for a panic reaction will increase. This can manifest itself in such a way that a person who has experienced a situation will, e.g. when driving on a slippery road, and not being sucessful in handling that, and afterwards not being trained to handle these situations, which out on the roads is combined with a deadly peril, in fact tend to react primitively and in panic when said person later, in a similar situation - maybe just because of fear and stress - is exposed to and experience said same situation. Even if the present drivers education often aims at getting the driver so careful that he or she does not have to have any skill there are always the risk of misjudgment and panic behaviours. By motorically "grow up and into" a vehicle and its driver initiated behaviour on the road and experience the g-forces created from a moving vehicle, a drivers brain will in a way be programmed slowly but safely to give a safe future reflex behaviour also in close escapes. The feeling of to belong or form a part of the vehicle will have that effect that the driver from the very beginning will be aware of that it is the drivers own presence of mind and skill that will influence how safely you travel, i.e. in the first place not the passive safety of the car and soft lampposts.

By starting the drivers training by driving a vehicle on slippery and maybe in incorrectly banked tracks the basic behaviour will be trained in a very effective manner. The exercises will continue in such a way that the novise driver all the time has such a control over the vehicle that

he or she in fact dares to proceed by trial and error and investigate what will happen when turning the steering wheel, when braking and when accelerating. Each new moment will build onto what has been previously trained. By using a computor supervision and mapping according to the teachings of the present invention it is possibel to record how the learning proceeds, i.e. how each exercise will be managed in view of the automatic behaviour. By comparing differences from an ideal drivers behaviour it is possible to find risky behaviours and from there adapt and maybe repete what is needed in a way being unique for a further development of each individual into a reliable road user.

A training in low speeds will without stress make it possible for the novis driver to register that something happens, directely followed by an awareness of what is happening. By repeting the exercises and try out different ways of reacting, an understanding of why the vehicle is behaving the way it is will be obtained and the driver can train a behaviour which means that for each performed manoeuvre the vehicle will behave in an expected way. In this examining and trying exercise it is allowed, not to say necessary to fail. This helps in building up the drivers self confidence in handling the vehicle in different situations.

The advantage of performing the exercise on a slippery ground will from the beginning make the driver experience how very small g-forces can make the vehicle loose its grip, i.e. the driver will have an experienced knowledge of such factors as frictional grip, choice of tires, driving performance of the vehicle and last but not least an understanding of the drivers own skill.

The training must take place by using real vehicles. To obtain an automatic behaviour by training it is very important that g-forces and changes in g-forces can be apprehended by the driver, as changes in g-forces experienced by the brain have a very strong influence on which reflexes are going to be released to arms and legs.

It has been proven that an introductory training on slippery tracks - for drivers who never will be in the risk of driving on slippery roads too - is of a great value as such an exercise/experience will give a healty respect for the mass forces appearing when driving a vehicle even if the road is not slippery.

By performing as suggested by the present invention there is a base to establish a recordable quality garantee of a drivers education when

it comes to the basic skill how to handle a vehicle, as well as the possibilty to later follow up and map each drivers change in these respects.

An other important aspect of the present invention is an application where a control of the drivers fitness to safely drive a vehicle can take place during a travel in progress.

The handling defaults of a novis driver are of different kinds, but many defaults can be classified to a motoric or psychomotoric incapability and are principally of the same kind for many novis drivers even tough two drivers will not have an identical behaviour regarding handling defaults and panic thresholds.

When it comes to drunken or drug affected drivers or drivers who are too tired to drive a vehicle safely their behaviours are characterized in a delayed reaction on outer stimuli, e.g. from a gust of wind. Normally the driver reacts automatically with reflexes on such a vehicle behaviour and an individual ability to a reflex reaction on such a vehicle behaviour may be stored in a memory card connected to a computerized supervising system in the vehicle and recording the handling of the controls and the performing g-forces. Thus such a memory card can contain the approved normal behaviour of the driver and this behaviour can continously be "in charge" and compared to the actual behaviour of the driver. If a too slow reaction appears from the driver this can cause an automatic reduction of the speed, or in severe cases that the vehicle simply stops at the same time as the warning lights turns on.

When it comes to exercises for novis drivers they will meet an incerasing degree of difficulties such that a gradually incerasing use of previously experiences will be needed from the driver all the time. The succesive exercises will build on earlier trained refexes and behaviour patterns which will be further strengthend and new patterns in connection hereto will created.

When necessary the driver can return to earlier basic exercises to further exercise a coordination of the movements of the body in connection to the handling of the controls and motorically secure these as reflexes. Thus one of the vital advantages with this training is to establish a reflex pattern of the driver garanteeing a high panic threshold, i.e. the reflex actuated manoeuvres of the driver will, dependent upon information recieved and dealt with, result in an intentional and wanted behaviour of the vehicle, i.e. the driver will - to a very little extend - be surprised by the behaviour of the vehicle, and thus risk to be struck by panic.

measure variable, and said standard deviation of the separate measure variable is inverted and is used as a scaling factor for said separate measure variable. Other types of scaling can also be used.

After said scaling the data matrix is divided in a calibrating set and in a test set, and after this the classifying modell is formed. This method is described below for an analysis of principal components and for neural networks.

The principal component analysis is a matematic tool to elucide the underlaying linear structures being found in the data to be analysed. The basic assumption is that each original variable cannot describe the complexibility of the problem studied, but that the substantial information is mixed in all the measure variables. In principal component analysis the goal is to perform an linear transformation of data into a sub space of a lower dimension. This calculated sub space is stretched up by the so called latent variables, i.e. the underlaying ortogonal information structures of measure data and is calculated secventially as the directions maximazing the explained covariance of measure data.

To define the direction on a coordinat axis in the calculated sub space the cosines are used against the axis of the original coordinate system. The vecor is called "loading". The positions of the separate observations in the calculated sub space will be scaled and are described afterwards as the position of the separate observation, lineary projected onto the calculated "loading" vectors. Said linear projecting onto a "loading" vector is mentioned as the "scores" values of the separate observation along each "loading" vector.

The most common pretreatment of measure data prior to principal component analysis is the above described auto scaling method.

The principal component analysis can be used in classification by studying the positions of the separate observations in the calculated sub space. According to what is said above the separate observations describing similar behaviours will form groups in the calculated sub space. The boundary aera of a group can be calculated by applying a Hotelling T2-test, provided that the separate groups can be identified, which in the precent case is secured by studying and recording the result of each separate driver.

Neural net work is a matematic outlook to describe the natural solution of learning, where the human brain is the primary prototype and consists of a number of neurons being connected into a net work. Depen-

dent of the arcitecture of said net work the neural net work will gain different functionalities. In this context a so called feed-forward neural net work will be described. Such a net work will consist of a number of layers. A separate neuron in a layer is connected to all the neurons in an earlier layer and to all neurons in a later layer. Said layer where measure data or preprepared measure data is introduced to the net work is called an input layer, the layer where the results is presented is an output layer and the layers in beween are called hidden layers.

The functionality in a separate neuron is to weight it to the incoming information to the separate neuron, to process the calculated scalar product over a transmitting function. Said transmitting function, commonly being not linear, e.g. the hyperbolicus or sigmod of the tangent will give the neural network its non linear properties.

The training of a nural network of the typ feed-forward means optimizing the arcitecture of neural network, i.e. the number of hidden layers and the amount of neurons in the separate hidden layers, and before an optimized arcitecture train said neural network to distinguish the different groups identified by measure data.

Measure data is preprepared with success by applying the above mentioned principal component analysis which will increase the speed of convergense at the training step of said neural network.

The classification for a feed-forward neural network will usually take place by "learning" the neural network to differentiate beween, in the present case, a skilful drivers behaviour and a poor drivers behaviour seen from a level of basic skill. I.e the different behaviours must be presented to the net work during the learning phase, which can be done by coding a good reflex behaviour with the value 1 (one), and a poor reflex behaviour with the value 0 (null), or vice versa. Thus for the trained neural network the nearness of the future predictions to the coded integer will describe the class belonging of the separate observation, i.e. the separate observation will belong to the group as being closest in prediction value.

Thus by present invention a method is disclosed to effectively train/map an ability of a driver to reflectively handle a vehicle. The multi variate analysis of collected information from several different measure variables is the one condition to get an overview of different behaviours or series of behaviours developed and are dependent on eachother and which in ceratain constellations will lead to a risky behaviour or to an

By mapping the drivers behaviour/the behaviour of the vehicle according to what is ment by the present invention it will be simple to use - in connection to this map - an interactive computerized mapping system where the actual handling pattern of the controls and the behaviours of the vehicle in an exercise will be compared with stored "correct" handling patterns of the controls, and from a difference, if any, between these patterns it is decided if the exercise is approved or not, i.e. if the exercise is performed in a safe or in an irresolute way. As the exercises are basic and in advance decided to be performed in connection to a specific training track, at the same time as the speed is low, the differences appearing will be fully managable and it will be possible to store suggestions to repete previous exercises in the memory of the computer in dependence of said actual difference which may indicated shortcomings in the drivers behaviour.

By comparing the driver behaviours of novis drivers or skilled drivers with recognized skilled and unskilled drivers, or with an average of serveral skilled drivers, bad and risky behaviours can be mapped at the same time as a contious follow up of a certain driver´s status regarding the skill to handle a vehicle is possible to perform.

The method to map the handling pattern can be connected to a system for positioning in such a way that the coordinates of the vehicle is continously recorded at the same time as the driver behaviour is mapped and recorded. This technique to continously decide the position of a vehicle may also be based on one or a couple of sensitive g-force recording means forming part of a computerized logging system and wherein the g-force recording means are of such a type that the position of a vehicle on a test track can be decided with a great accuracy. An example of such g-force recording means with a digital output is sold by Analog Devices, Inc., USA. One possibility to relate the drivers behaviour to an actual position on a track will also allow a comparision between the behaviour of a trainee and a choosen "ideal" driving behaviour on the one and same position on the track, i.e. in a way making a comparision between said behaviours meaningful. The coosen ideal driving behaviours can be on different skill levels dependend upon what type of drivers education or completing training is aimed at.

One explanation how the great amount of recorded variables being logged during one training occation ought to be handled shall be described in the following.

If each measured variable is allowed to bescribe an axis of a coordinate in a sphere the propotions of which is the same as the numbers of variables, each vector at each recording will be a point in this sphere. Observations look alike will be close in this sphere, thus the distance will form a measure of similarity/divercity. This means that observations (measures) with a safe behaviour will be grouped close to each other in this sphere while observations with a risky behaviour will form their own groups. By performing the exercises during different conditions (e.g. with the wrong tire pressure or with the wrong tire combination and on different road conditions) specific groups of risky behaviours can be formed, provided that the driver is not trained to handle these situations with a "deviating" behaviour of the vehicle. If, not look upon each observation as a point of time and instead look upon it as a position on the track there will be a measure of the driving behaviour as a direct result of the position on the track, e.g. at straights, curves, upphills and down-hills, i.e. at places where the driver easily can get into situations where the lateral g-forces will be too great to keep the vehicle left on the track, i.e. if the speed is choosen too high or too low. Thus it shall be noted that with extreme slippery tracks it may be easy to slid off the track in curves (due to the banking of the curve), if not a counter directed g-force is created by a speed being enough for this to happen.

For a specific track the map coordinates, or other information of the position of the vehicle on said track, and vectors with measure data, will together with the way of looking upon it as described above, form the base for the classifying system wherein the driver behaviours, mapped from the track, can be compared with the behaviour of a discerning and skilled driver as mapped at the same or at a similar track. The classification can be done with different kind of multvariable-mathematic techniques as discriminating analysis or analysis of the principal components or with the aid of a neural net work.

In common for all these methods is that some form of scaling is done prior to the mathematic modelling. It is common to use the so called autoscaling method, which results in that the separate measure variables is centered and scaled to the standard deviation 1 (one). The centering of the different measure variables will take place by calculating the mean value of the separate measure variable and that this mean value is substracted from the separarte measure variable for each separate observation performed. After this the standard deviation is calculated for each separate

uncontrolled behaviour of the vehicle. The other condition is the comparison with a "corrct" behaviour by performing the driving exercises on a certain test track where it will be a restricted amount of possible behaviours of the driver and of the vehicle.

One practical application of the invention suggests that "standardized" training tracks are used with the possibilty to train manoeuvres of different degerees of difficulty on different kind of trying (slippery) road conditions. By at a very early stage begin the drivers training on slippery roads a very good ability of the driver will develope to notice vehicle behaviour in the interface gripp/slipperiness, i.e. the risk for panic to develope in such situations later on in life will substantially be eliminated.

When a driver has finished his or hers practice drivning with appropiately suited (predetermined) manoeuvres, speeds and road conditions, the recorded information (data) of the practice drivning may be stored in a memory card, e.g. connectable to a personal computer. A connection to a main computer having the capacity to "judge", i.e. a big memory with stored practice drivings of corresponding type from different kind of skilled drivers, will in infact make it possible to find out, from the recorded differences, if any, between an ideal behaviour and the actual behaviour about shortcomings in the handling of the controls and in the perception, and to suggest suitable exercises assisting the driver to overcome these shortcomings. Thus information can be transferred back to the memory card of the driver/trainee with these suggested new exercises. The next time when the trainee comes to the training track these exercises will be automatically suggested by an interactive computer system at said training aera. Suitable exercises are determined and a suitable driving path through the training aera is settled to eliminate the discovered shorcomings of the driver.

CLAIMS

1. A method to map the control handling pattern of a driver regarding basic skills during training and/or regarding fitness to drive a vehicle, **characterized in** that comparing and predicative matematic models are used which models being obtained by using a multi variate data analysis of the information flow of continously recorded information in connection to a correct vehicle behaviour during travel of a predetermined test track and during predetermined and set conditions.

2. Method according to claim 1, **characterized in** that deviations or a combination of deviations obtained by performing one sequence of said test track regarding degree and presence are stored as consequense models in the memory of the computer and form the basis for determining if the actual drivers performance or an exercise shall be approved or not, and to instruct the driver to perform new exercises, or repeat earlier exercises, or alternatively to be exposed to new hidden manipulations of the vehicle and/or the controls.

3. Method accordning to claim 1 or 2, **characterized in** that collection of the control handling pattern from several drivers on said track is done in the form of numeric data for several parameters, as g-forces, handling of the controls, and the vehicle position on the track,

that the scaling of said data matrix is performed prior to a matematic modelling, which result in that the separate measure variables ara centered and scaled to the standard deviation 1 (one),

that the centering of a single measure variable takes place in that the mean value of the separate variable is calculated and that this mean value is substracted from the separate measure variable for each separate observation,

and thereafter that the standard deviation of each separate measure variable is calculated, the standard deviation of the separate measure variable is inverted and used as a scaling factor for the separate measure variable.

4. Method according to claim 3, wherein an artificial network is established in a computer and adapted to the numbers of measure variables and control handlings and behaviours of the vehicle and/or the driver,

wherein said neural network has an input layer, one or several hidden layers and one output layer.

5. Method according to claim 4, wherein bringing the electronic information from the neural network in line with the numeric information in accordance to adjustable parameters at the neural network, whereby the artificial neural network is trained by the computer to automatically give an analytic model.

6. Method according to claim 5, wherein information is logged from the drivers training with a new driver and comparing said information with perviously stored, and by said neural network processed information, whereby said new information is automatically scaled to the information already existing in the system and to feed the scaled new information to the trained neural network and from that network obtain a mapping over the behaviour of the new driver concerning the fitness and/or safety of the driver to drive a car.

7. Establishment to instruct trainees in connection to learning a reflective handling of a vehicle and to perform the method according to claim 1, and including;

a vehicle with a drivers seat,

means to record the handling of the controls and to transfer said information to a CPU in the memory of which consequense models of different kind of behaviour combinations of both drivers and the vehicle are stored;

g-force recording means being used in practical trials with vehicles which means that during a measuring period continously recording the g-force especially in the horisontal plane during the performing of an exercise,

characterized in

that the consequense models in the memory of the computer contains stored graphs corresponding to a correctly performance of said exercises, whereby the computer is programmed to compare stored g-force patterns, virtual or actual, with stored and correct patterns, whereby deviation patterns between said two patterns are stored and which represent common behaviour errors in connection to novis drivers behaviour.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 99/02207

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: G09B 9/052, G09B 19/16
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: G09B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC, WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	GB 2286369 A (SOLVIT SCIENTIFIC ENGINEERS LIMITED), 16 August 1995 (16.08.95), the whole document --	1-7
X	EP 0633552 A2 (AUDI AG), 11 January 1995 (11.01.95), the whole document --	1-7
A	US 5269687 A (S.J. MOTT ET AL), 14 December 1993 (14.12.93) --	1-7

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
2 March 2000	06-04-2000
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Christer Bäcknert / MR Telephone No. +46 8 782 25 00

International application No.
PCT/SE 99/02207

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT
Information on patent family members

02/12/99

International application No.
PCT/SE 99/02207

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